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The fluorescence method of Sweat for the determination of hydrocortisone and a corticosteronelike fraction in blood was utilized in an attempt to evaluate flying fatigue in a group of 44 aircrewmen participating in flying activities in military aircraft. Preflight values for each of the two steroid fractions agreed with those of Sweat for normal male subjects, but significant increases in both fractions were noted after flights of 9 to 12 hours' duration. These changes are not of the nature of normal diurnal variations.

Prolonged flights in military aircraft result in a state of fatigue which, subjectively, may be extreme; yet the underlying physiologic changes are unknown. Evidence of adrenocortical involvement has been obtained by Marchbanks (1), who noted increased urinary excretion of 17-hydroxycorticosteroids in a group of aircrewmen during a 22½-hour flight. The purpose of the present study was to test the possibility that blood corticosteroid levels in fatigued aircrewmen become elevated.

METHODS

The fluorescence method of Sweat (2) for the detection of hydrocortisone and corticosteronelike fraction was employed. Pre- and postflight venous blood samples were obtained from 44 men (members of 9 crews) participating in training flights lasting 9 to 12 hours in B-52 aircraft. All flights began in the morning, with the earliest one starting at 0730 and the latest at 1200 hours. Preflight blood samples were taken at least 1½ hours before the start of the flight, because this was the time at which the crews entered their aircraft to begin preflight preparations; they would not be accessible again for test procedures before takeoff. Postflight blood samples were taken about 30 minutes after the end of the flights. All of the flights were rated as successful and without any unusual event. Cabin altitude at no time exceeded 10,000 feet.

RESULTS

Mean preflight values for each of the two steroid fractions (table 1) are in excellent agreement with those obtained by Sweat (2, for 21 normal male subjects. His values were 10.8 ± 0.6 and 4.3 ± 0.5 µg. per 100 ml. plasma for hydrocortisone and the corticosteronelike fraction, respectively. Mean postflight values for each of the fractions proved to be significantly different from Sweat's values ($P < .01$). The mean gain for each of the two fractions was analyzed statistically and found to differ significantly from zero ($P < .01$). Only one of the 44 subjects showed a decrease, and this involved hydrocortisone only. In this particular case, preflight values for both fractions were relatively high (20.8 and 7.4 µg. for hydrocortisone and the corticosteronelike fraction, respectively). While the hydrocortisone value (19.2 µg.) after the flight was lower than previously, it was still a relatively high value. The final corticosteronelike fraction after the flight (8.1 µg.) was also relatively high.

Mean values for those crew members who were instructors did not differ from those who were in training; nor were there significant differences between crew members in different categories – namely, Aircraft Commander, Pilot, Navigator, Electronics Countermeasure Operator, and Gunner.

DISCUSSION

In attempts to assess flying fatigue during long-range flights, Murphy et al. (3) used an older method for the determination of urinary corticoids and obtained equivocal results. With a more sensitive and precise method, Marchbanks (1) found the urinary 17-hydroxycorticosteroid values during an extremely long flying mission (22½ hours) in B-52 aircraft to be significantly higher than on nonflying days. In the present study on B-52 crew members, flight times were approximately half as long as in Marchbank's study; still,

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TABLE I

Plasma corticosteroid change in aircrewmen during long flights

Crewman	Hydrocortisone (F)			Cortisonelike fraction (B)			Ratio F/B	
	Preflight	Postflight	Gain	Preflight	Postflight	Gain	Preflight	Postflight
1	7.6	9.7	+2.1	3.0	4.7	+1.7	2.53	2.06
2	8.5	11.2	+2.7	3.5	3.8	+0.3	2.42	2.94
3	7.5	7.7	+0.2	2.7	3.4	+0.7	2.77	2.26
4	8.5	10.6	+2.1	3.1	4.9	+1.8	2.74	2.16
5	9.0	14.2	+5.2	3.6	6.6	+3.0	2.50	2.15
6	7.4	11.8	+4.4	3.1	4.1	+1.0	2.38	2.87
7	9.7	17.1	+7.4	3.1	4.4	+1.3	3.12	3.88
8	8.4	9.9	+1.5	3.6	5.3	+1.7	2.33	1.86
9	10.0	15.3	+5.3	3.1	5.6	+2.5	3.22	2.73
10	17.6	23.7	+6.1	8.4	10.8	+2.4	2.09	2.19
11	20.8	19.2	-1.6	7.4	8.1	+0.7	2.81	2.37
12	14.1	29.8	+15.7	5.3	11.1	+5.8	2.66	2.68
13	15.7	22.9	+7.2	7.0	9.6	+2.6	2.24	2.38
14	8.9	12.9	+4.0	4.1	6.0	+1.9	2.17	2.15
15	14.1	27.3	+13.2	6.9	10.2	+3.3	2.04	2.67
16	13.5	18.1	+4.6	4.5	6.9	+2.4	3.00	2.62
17	12.2	19.8	+7.6	6.4	9.9	+3.5	1.90	2.00
18	10.8	14.7	+3.9	4.2	7.4	+3.2	2.57	1.98
19	12.0	13.7	+1.7	6.6	7.4	+0.8	1.81	1.85
20	8.8	14.1	+5.3	3.7	6.8	+3.1	2.37	2.07
21	9.2	21.3	+12.1	7.6	8.1	+0.5	1.21	2.62
22	11.9	22.8	+10.9	6.5	15.3	+8.8	1.83	1.49
23	12.0	13.8	+1.8	5.2	8.0	+2.8	2.30	1.72
24	8.9	24.9	+16.0	3.4	13.6	+10.2	2.61	1.83
25	10.7	18.8	+8.1	3.5	8.0	+4.5	3.05	2.35
26	11.8	15.2	+3.4	5.2	5.8	+0.6	2.26	2.62
27	13.4	19.9	+6.5	5.2	6.2	+1.0	2.57	3.20
28	12.3	19.5	+7.2	4.6	5.3	+0.7	2.67	3.67
29	9.0	12.9	+3.9	5.9	6.3	+0.4	1.52	2.04
30	9.8	11.1	+1.3	3.2	5.6	+2.4	3.06	1.98
31	13.0	16.7	+3.7	5.2	5.8	+0.6	2.50	2.87
32	10.1	17.9	+7.8	4.9	7.3	+2.4	2.06	2.45
33	19.7	23.7	+4.0	7.1	8.8	+1.7	2.77	2.69
34	11.1	16.9	+5.8	3.5	6.4	+2.9	3.17	2.64
35	7.5	7.9	+0.4	5.4	6.6	+1.2	1.38	1.19
36	10.3	18.5	+8.2	4.5	6.8	+2.3	2.28	2.72
37	10.4	14.5	+4.1	4.7	6.8	+2.1	2.21	2.13
38	11.3	17.2	+5.9	4.4	5.1	+0.7	2.56	3.37
39	13.2	16.7	+3.5	5.1	7.6	+2.5	2.58	2.19
40	13.3	18.3	+5.0	6.0	7.5	+1.5	2.21	2.44
41	11.6	18.2	+6.6	4.7	6.2	+1.5	2.46	2.93
42	12.5	18.8	+6.3	5.5	7.3	+1.8	2.27	2.57
43	9.2	15.0	+5.8	4.8	6.8	+2.0	1.91	2.20
44	11.0	13.7	+2.7	4.4	5.3	+0.9	2.50	2.58
Mean	11.3	16.8	+5.4	4.8	[illegible]	+2.3	2.40	2.42
S. E.	0.45	0.75	0.57	0.22	0.36	[illegible]	0.068	0.080
P			<.01			<.01		

Values expressed as micrograms per 100 ml. plasma.

both sets of results suggest functional changes involving corticosteroids. While it would have been very advantageous to have taken urinary samples along with the blood determinations in the present study, operational problems prevented us from doing so. Furthermore, while blood determinations on nonflying days would have been of great value, scheduling difficulties made this impractical. Nevertheless, the use of preflight values established that, as a group, these men had normal values initially and that a significant increase occurred. That this increase is not of the nature of a diurnal variation is clear, since others (4, 5) have found that plasma 17-hydroxycorticosteroid values in normal persons tend to decrease throughout the period of the day in which these flights took place. Since Romanoff et al. (6) noted that the diurnal rhythm in the urinary excretion of total 17, 21-dihydroxy-20-ketosteroids, tetrahydrocortisol, and tetrahydrocortisone in Air Force bomber crew members engaged in flying activities did not differ from that of nonflying, normal subjects, it appears that urinary and blood indices of adrenocortical function are not equally sensitive.

While Sweat (2) stated that the ratio for the two fractions of steroids varies widely among individuals and does not appear to conform to any pattern, the mean preflight hydrocortisone/corticosteronelike ratio for these subjects was 2.40 ± 0.068 and the postflight value was 2.42 ± 0.080. While for individuals, pre- and postflight ratio values varied and different patterns of change were seen, as a group the constancy is striking – especially so because the method emplo' ' for the corticosteronelike fraction gives values which are high as compared with those obtained by Peterson's method (7) for corticosterone.

From the report of Brown et al. (8) that plasma concentrations of free 17-hydroxycorticosteroids are influenced more by the rate of removal from plasma than by the adrenal response to ACTH – at least in patients with metabolic disorders – it does not seem safe to interpret these elevations in plasma corticosteroids in fatigued men as evidence of adrenocortical stimulation. Wallace et al. (9) reported cases of patients with renal disease who had elevated blood levels of corticosteroids and low urinary values; thus under certain conditions the two measures may fail to give the same indication. We do not imply that renal or metabolic disorders develop from flying activities, but the above-mentioned points emphasize that the changes in plasma steroid fractions may represent changes other than those resulting from ACTH release.

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